SHORT PAPER

DIMETHYLNITROSAMINE IN SOUSE AND SIMILAR JELLIED CURED-MEAT PRODUCTS

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Summary—Dimethylnitrosamine was found in eight of ten samples of commercial souse and similar gelatin-containing cured-meat products at levels ranging from 3 to 63 μg/kg. One of the samples was also found to contain 19 μg nitrosopyrrolidine/kg. There appeared to be no correlation between residual levels of sodium nitrite and the nitrosamine concentration. The nitrosamines were determined quantitatively by gas–liquid chromatography (glc) using an alkali flame ionization detector and the analyses were confirmed by glc–high resolution mass spectrometry.

Introduction

A paucity of information is available on the presence of nitrosamines in the human diet. Accumulation of such data is important so that the contribution of nitrosamines to human health hazards can be assessed properly. Several volatile nitrosamines, particularly dimethylnitrosamine (DMNA) and nitrosopyrrolidine (NPy), have been confirmed by mass spectrometry in a variety of cured-meat products (Crosby, Foreman, Palframan & Sawyer, 1972; Fazio, White, Dusold & Howard, 1973; Fazio, White & Howard, 1971; Panalaks, Iyengar, Donaldson, Miles & Sen, 1974; Sen, 1972; Sen, Donaldson, Iyengar & Panalaks, T. 1973; Wasserman, Fiddler, Doerr, Osman & Dooley, 1972). For the most part, the positive samples occurred in a random fashion and contained μg/kg (ppb) concentrations of nitrosamines.

Prior to the finding of NPy in fried bacon (Crosby *et al.* 1972; Fazio *et al.* 1973; Sen *et al.* 1973), it had been suggested that the pyrolysis of protein and the cooking of protein food might produce free amino acids, such as proline, hydroxyproline and arginine and nitrosatable secondary amines, such as pyrrolidine and piperidine (Lijinsky & Epstein, 1970). Bills, Hildrum, Scanlan & Libbey (1973) and Pensabene, Fiddler, Gates, Fagan & Wasserman (1974) reported that NPy was formed in model systems from the decarboxylation of nitrosoproline at temperatures used for frying. Recently, workers in our laboratory identified nitrosoproline in uncooked bacon (Kushnir, Feinberg, Pensabene, Piotrowski, Fiddler & Wasserman, 1975). In addition, we found NPy in the adipose tissue but not in the lean tissue of fried bacon. As a result, we have suggested that collagen may be responsible for NPy formation in fried bacon (Fiddler, Pensabene, Fagan, Thorne, Piotrowski & Wasserman, 1974). Huxel, Scanlan & Libbey (1974) produced NPy from samples of buffered collagen (from bovine achilles tendon) and $NaNO_2$ at temperatures of 120–195°C in a model system. Collagen, the major constituent of skin, tendon and connective tissues, contains large concentrations of glycine, proline and hydroxyproline and is the most abundant mammalian protein (Bodwell & McClain, 1971). Gelatin is commonly prepared by the alkaline treatment of collagen (Fysh, 1958). Gelatin, therefore, may serve as a source of nitrosatable proline, and the product may convert to NPy under certain conditions.

There are a number of meat products made with gelatin and cured non-skeletal and organ meats. This paper reports a limited survey designed to determine the presence of volatile nitrosamines in such products.

Experimental

Seven samples of souse, two of blood and tongue and one of head cheese, produced by seven different manufacturers, were purchased in local retail outlets. Details of the ingredients and processing and storage conditions of these samples were unknown.

These samples were analysed for six volatile nitrosamines, namely DMNA, methylethylnitrosamine, diethylnitrosamine, nitrosopiperidine, NPy and nitrosomorpholine. Concentrations as low as 0·5 μg/kg could be detected and 3 μg nitrosamine/kg could be confirmed by mass spectrometry. Only DMNA and NPy were confirmed by matching the gas–liquid chromatographic (glc) retention times with those of authentic nitrosamines and by peak-matching the exact masses of the nitrosamine parent ions, m/e 74·0480 and 100·06366, respectively, using perfluorokerosene as an internal standard. The procedures for the isolation, separation, detection and confirmation of volatile nitrosamines, including information regarding recoveries from spiked samples, glc and glc–high resolution mass spectrometric conditions have been published elsewhere (Fiddler *et al.* 1974; Kushnir *et al.* 1975; Pensabene *et al.* 1974).

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Precaution should be exercised in the handling of nitrosamines, since they are potential carcinogens.

Results and Discussion

The results of the nitrosamine survey are shown in Table 1. DMNA was confirmed in six of the seven samples of souse and in both samples of blood and tongue in concentrations ranging from 3 to 63 μg/kg. The presence of NPy (19 μg/kg) in one sample of souse was confirmed by mass spectrometry. The sample of head cheese contained no detectable nitrosamine. Residual nitrite varied in the samples from no detectable amount to 135 μg/kg, but there appeared to be no correlation between residual $NaNO_2$ content and the DMNA concentration found.

Table 1. *Nitrosamines in souse and similar products*

Type	No.	Residual $NaNO_2$ (mg/kg)	Content of nitrosamines* (μg/kg)	
			DMNA	NPy
Souse	1	12	26	19
	2	118	63	ND
	3	39	3	ND
	4	4	5	ND
	5	3	6	ND
	6	27	6	ND
	7	ND	ND	ND
Blood and tongue	1	5	45	ND
	2	135	7	ND
Head cheese	1	15	ND	ND

DMNA = Dimethylnitrosamine ND = None detected
NPy = Nitrosopyrrolidine
*Identity confirmed by mass spectrometry.

In a general method for the preparation of souse, non-skeletal meats previously cured with nitrite or nitrite–nitrate are ground through a 1-in. plate and then mixed with gelatin, broth, vinegar and spices. The mixture is heated to 74°C (165°F), poured into moulds and chilled to solidify (Kramlich, Pearson & Tauber, 1973). This temperature is considerably lower than the 185°C (365°F) optimum temperature reported for the decarboxylation of nitrosoproline to NPy (Pensabene *et al.* 1974).

Lecithin (Möhler & Hallermayer, 1973; Pensabene, Fiddler, Doerr, Lakritz & Wasserman, 1975) and its decomposition products (Pensabene *et al.* 1975) have been shown to form DMNA when reacted with nitrite in model systems. Since non-skeletal tissues may contain higher concentrations of lecithin than does skeletal tissue (Dugan, 1971), the former may be a source of DMNA.

The nitrite available for nitrosamine formation could arise from the initial cooking of the cured non-skeletal meats; the broth resulting from the tenderizing process may be used in the preparation of souse.

Currently our laboratory is investigating the source of DMNA in products containing gelatin. While the jellied products described in this paper constitute only a very small portion of the total production of cured meats in the United States, they may play a more important dietary role elsewhere.

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